

Colocation of Electronics with Microfabricated Actuators

This project will bridge the gap between micro-electro-mechanical systems (MEMS) sensors and the electronics necessary to control and extract data from them. Since the advent of MEMS, macroscopic wires have connected MEMS devices to electronics for control and sensing. The parasitic capacitance of these wires, the sheer number of wires sometimes necessary, and the additional volume required by wires and a second chip, makes macroscopic wires an unacceptable solution for many projects.

Several groups have produced MEMS devices on the same chips as electronics by putting the electronics next to the MEMS, or by using exotic materials that can be deposited without exceeding the thermal budget of the electronics. However, one often needs to fabricate MEMS devices that are incompatible with the exotic materials, and dense arrays of devices cannot tolerate the space used by placing MEMS next to electronics. The advent of the ability to bond chips together with microfabricated metal

bumps will allow MEMS structures to be fabricated in conventional processes and then bonded to their controlling electronics.

Project Goals

This project demonstrates a technology to colocate MEMS with electronics. To do this we need to produce a test MEMS device and electronics, and colocate the two. We use the spatial light modulator (SLM) as a test system. The SLM has the advantage that it benefits from both the scalability and the increased sensitivity of colocation. Our goal was to produce a 19-pixel array of actuators attached to electronics.

Figure 1 is a schematic of the bonding process.

Relevance to LLNL Mission

This project has relevance to a variety of LLNL areas of interest. The work will enable sensors that require large arrays, are sensitive to parasitics, or require very small packages. This project will also extend mesoscale fabrication capabilities.

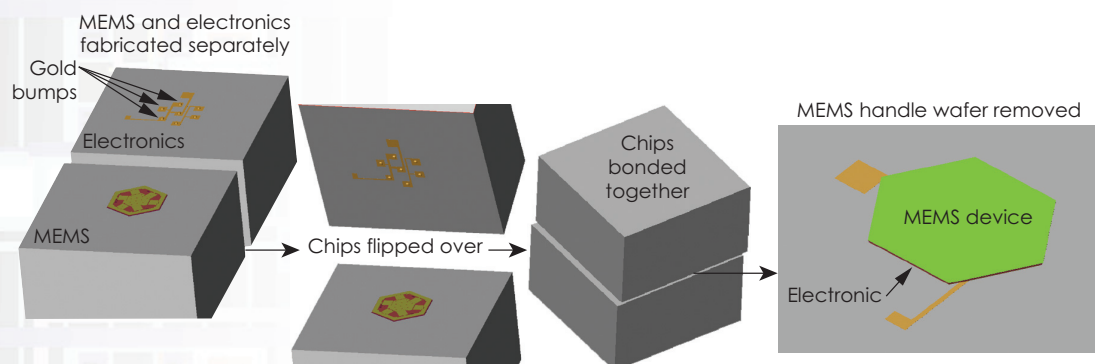


Figure 1. Schematic of bonding process.



For more information contact
Alex Papavasiliou
 (925) 423-1952
 papavasiliou1@llnl.gov

FY2005 Accomplishments and Results

This year the project moved toward the goal of bonding MEMS actuators to complementary metal oxide silicon (CMOS) circuitry. The high-voltage configuration was completed. We prepared application-specific integrated circuits (ASIC). Files with the parameters of the technology to be used were created. Following the production of the technology files, the circuit was simulated using SPICE software, the chip was laid out (Fig. 2), and the layout was simulated to determine that it would produce the expected results.

The MEMS actuators were reconfigured such that they would be compatible with the wafer release process as well as the electronics. The reconfiguration (Fig. 3) is complete and ready for fabrication.

Related References

1. Singh, A., D. A. Horsley, M. B. Cohn, A. P. Pisano, and R. T. Howe, "Batch Transfer of Microstructures Using Flip-Chip Solder Bonding," *Journal of Microelectromechanical Systems*, **8**, 1, pp. 27-33, March 1999.
2. Humpston, G., and S. J. Baker, "Diffusion Bonding of Gold," *Gold Bulletin*, **31**, 4, 1998.

FY2006 Proposed Work

For FY2006, we will fabricate the MEMS actuators in parallel with plans for a second-generation of electronics with a digital multiplexer. When the MEMS has been completed and the first ASIC returns from the foundry, they will be bonded together. Finally, a third-generation ASIC with capacitive position sensing will be fabricated and bonded to the MEMS actuators. This generation of ASIC will be capable of driving the MEMS actuators with a voltage based on the sensed position, providing closed-loop control.

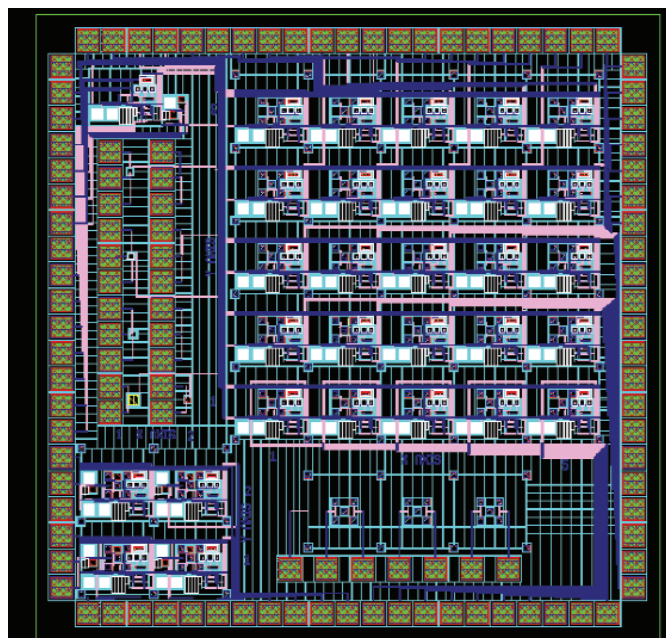


Figure 2. Layout for ASIC currently in fabrication. Upper right: 5-x-5 voltage-driver array; bottom left: 2-x-2 voltage-driver array; bottom middle: 1-x-3 direct-voltage array; top left: test circuits.

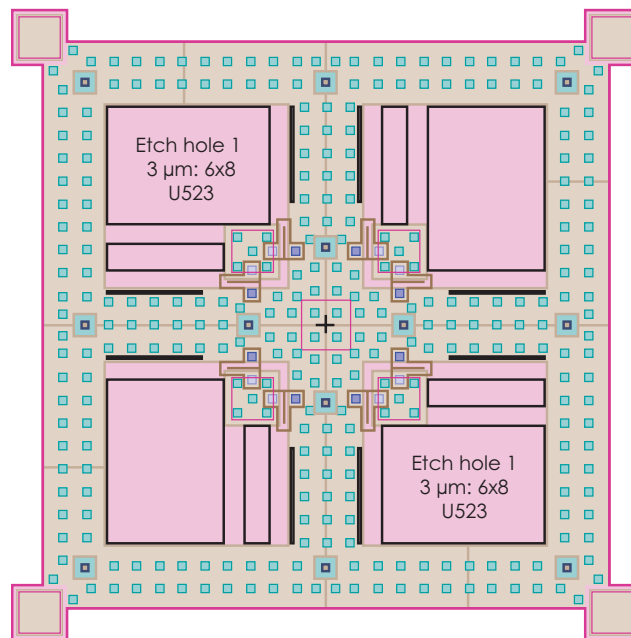


Figure 3. Layout for a MEMS actuator.